

[54] **ABRASIVE MEANS AND METHOD OF MANUFACTURE**

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[58] Field of Search **51/298, 295, 296**

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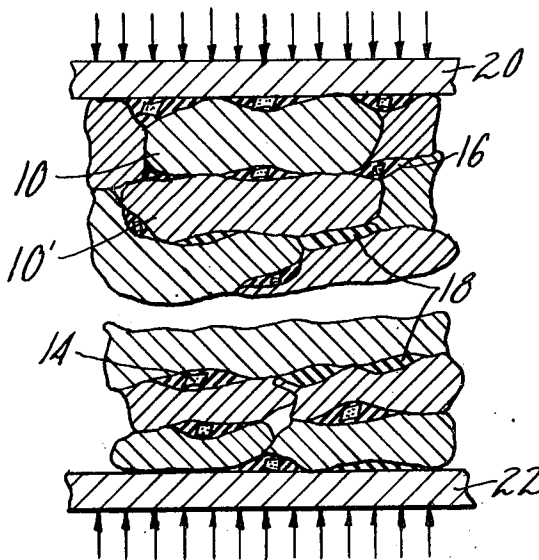
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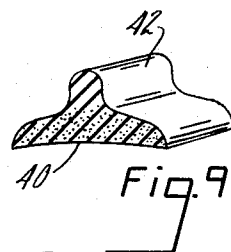
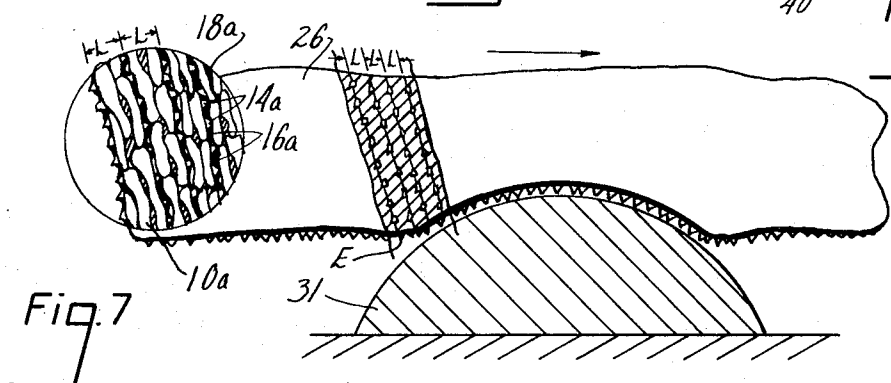
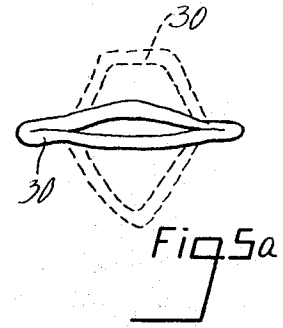
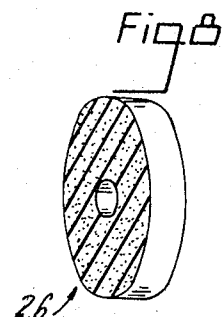
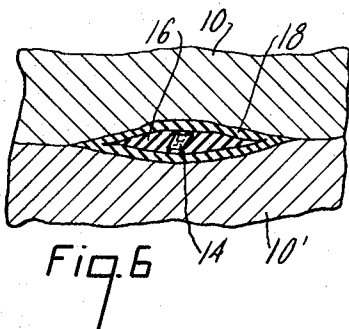
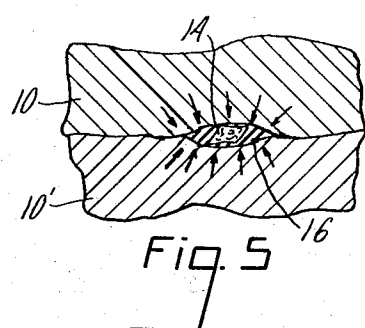
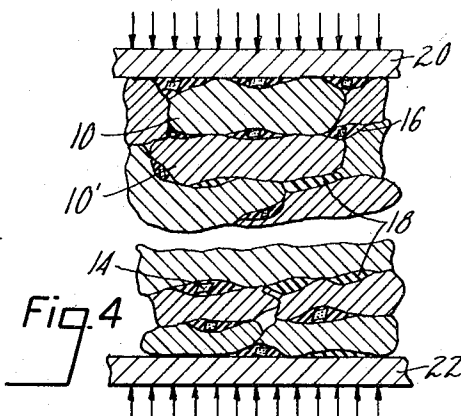
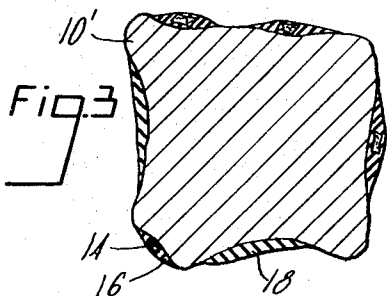
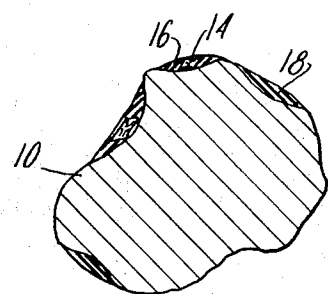
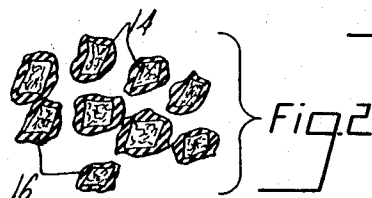
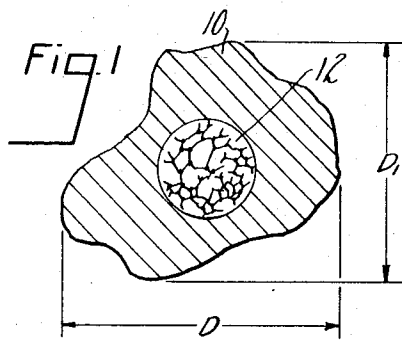
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ABSTRACT

Abrasive members formed with resiliently extensible and compressible preformed synthetic foam body particles compressed and bonded together with flexible bonding material and carrying abrasive grains. The combined void portion of the abrasive member and the solids portion of the foam particles occupies a substantial part of the total volume of the abrasive member, and more than 50% for members capable of conforming to contours. In one method of manufacture free preformed foam particles and abrasive grains are tumbled in the presence of tacky bonding material and the mix is thereafter compressed and cured.

2 Claims, 10 Drawing Figures





ABRASIVE MEANS AND METHOD OF MANUFACTURE

This application is a continuation of application Ser. No. 753,253 filed Aug. 16, 1968, entitled Abrasive Means and Method of Manufacture, now abandoned, which in turn is a continuation in part of application Ser. No. 456,647 filed May 18, 1965, of like title, now abandoned.

This invention relates to resilient abrasive members capable of use in the grinding, cleaning, polishing and surface finishing of articles.

A principal object of the invention is to provide an abrasive member that combines good abrading or cutting ability with resiliency to permit rapid and accurate stock removal and finishing of a wide variety of articles including, in particular, contour shapes.

Another object of the invention is to provide an abrasive member capable of producing unique and improved decorative scratch and other surface finishes.

Other objects of the invention are to provide resilient abrasive members that are improved from the points of view of low cost of raw materials; simplicity, lack of criticality, and low cost of forming procedures; and adaptability of the raw materials and forming procedures to the production of a wide range of different abrasive members.

Another object of the invention is to provide a means for forming an abrasive member which permits considerable time to elapse between the various steps, and in particular permits mixing in sizeable batches, with subsequent molding in smaller quantities over a considerable period of time after mixing.

Other objects of the invention are to provide abrasive members that are improved from the points of view of durability; strength and resiliency; uniformity of abrasive qualities; ability to maintain a clear line between finished and unfinished areas, and ability to operate under high speed and high pressure conditions.

Still other objects of the invention are to provide improved abrasive member constructions that are adaptable to floor scrubbing, wood sanding, deburring of metal pieces, removing parting lines from zinc die castings and the like.

As examples of some articles that can be finished with abrasive members of the present invention there are turbine blades, cosmetic cases, lipstick shells, eyebrow pencil cases, door knobs, light switch covers, sink spouts and handles, automobile grills, handles and lens frames, and numerous other decorative and functional items formed of metals such as zinc, brass, copper, aluminum, titanium and stainless steel. Examples of wooden articles that can be finished with abrasive members of the present invention are wood moldings and intricate furniture parts.

These and numerous other objects and features of the invention will appear in the following description and the accompanying drawings wherein:

FIG. 1 is a diagrammatic cross-sectional view, on a substantially enlarged scale, of a preformed resilient body member for use in the formation of an embodiment of the invention, with an encircled portion shown on an extremely magnified scale;

FIG. 2 is a diagrammatic cross-sectional view, on a substantially enlarged scale, of treated abrasive grains for use in the formation of an embodiment of the invention;

FIG. 3 is a view similar to FIG. 1 of two body members as illustrated in FIG. 1 combined with the abrasive grains of FIG. 2, this being a second stage of the formation of an embodiment of the invention;

FIG. 4 is a cross-sectional view, on the same scale as FIG. 3, illustrating the compression of the body members of FIG. 3 to their final form;

FIG. 5 is a cross-sectional view of a portion of FIG. 4 on a further enlarged scale;

FIG. 5a is a diagrammatic view on still a more enlarged scale of a foam cell within a compressed body member.

FIG. 6 is a view similar to FIG. 5 of another preferred embodiment;

FIG. 7 is a diagrammatic view illustrating the conformability to a work piece of an abrasive member formed according to the present invention;

FIGS. 8 and 9 are cross-sectional, perspective views, on reduced scale, of preferred resilient abrasive members of the present invention.

According to the invention, the abrasive member includes flexible bonding means, a large number of abrasive grains, and a large number of preformed discrete resiliently extensible and compressible foam body members of substantially greater size in the uncompressed condition than the grains. The discrete foam body members are preformed of resilient or elastomeric synthetic foam, most preferably scrap foam. (In this context "foam" is intended to include open as well as closed cell materials.) In the abrasive member, these preformed body members reside in a state of compression, with a substantially reduced size from their uncompressed state. They are joined together by a flexible bonding material into a flexible coherent mass in which the bonding material and the foam body members can flexibly distort together under working stress. In general, the portion of the volume of the abrasive member attributable to avoid space and the solids portion of the foam particles should be within 25 percent and 80 percent of the total volume of the abrasive member, and in most abrasive members capable of substantially conforming to contours, this portion of the volume of the abrasive member should exceed 50 percent. Furthermore, in preferred embodiments, at least a large number of the abrasive grains are secured to the discrete body members in a pressure of force-bonded relationship, which results from substantial compressive force being applied to the bonding material lying between the preformed discrete body members and the abrasive grains.

It is surprisingly found that the large number of preformed foam body members can be tumbled in the presence of the needed substantial quantity of bonding material. By such tumbling in the presence of the tacky bonding material, the grains, even though each has a very substantial weight compared to an individual foam body member, can be evenly distributed in the mixture and bonded in position, as shown in FIG. 4.

As a possible alternative, in some instances successive layers L each made up of compressed discrete foam body members bonded together can be provided, to the exterior of which abrasive grains are thereafter bonded under pressure. (See FIG. 7)

It is to be realized that this invention is quite different from prior compositions formed by the foaming of a mixture containing abrasive grains. In such compositions it is difficult to uniformly distribute the heavy

abrasive grains and to adequately secure them in place. Also, the exertion of compressive force upon the fluid being foamed is antagonistic to the required expansive and foaming action of the fluid. Accordingly, such constructions have necessarily involved detrimental compromises. In the present construction such compromises are avoided.

Because of preformation of the foam cells, it is possible to achieve the optimum resilient cellular nature of the body member, and to preserve it while achieving a considerable degree of compression and force-bonding of the abrasive grains. The freedom of resilient action of adjacent parts of the resilient cells of the foam need not be lost where the sides of the cells are compressed together so much as to contact each other. This is especially so since the bonding material need only be concentrated in the vicinity of the abrasive grains and periphery of the body members, and need not fill the interior of the body members, which is to say that a substantial volume of voids remains in the abrasive member. Hence it is possible to produce a substantially coherent abrasive article, while nevertheless retaining the flexibility attendant with that of the resilient cells of the preformed foam construction.

Furthermore, because preformed foam body members offer resistance to compression, it is possible, even with an extremely low density mass of foam, nevertheless, to obtain a force-bonded relationship between the abrasive grains and the discrete body members by the exertion of compressive pressure on the mass during molding.

Another advantage of the invention exists with regard to uniformity. When foamed in situ, according to the prior art there is a tendency with synthetic foams to have a thickened and less foamy consistency at the outer surface, causing the abrasive member to lack uniformity of flexibility and abrasive action. This disadvantage is avoided and peripheral portions can be made uniform with internal portions according to the present invention.

Another distinct advantage of the invention is the ability to utilize very low density foam compositions. The low density foams are widely available and low in cost due to their wide usage in the bedding or upholstery field. Thus, for example, urethane bedding foams of a density of less than 5 pounds per cubic foot, preferably on the order of 2 pounds per cubic foot, may be employed.

Another advantage of the invention is the fact that various foams having differing characteristics with regard to density, chemical composition or type of cellular construction can be intermingled. Thus, in the case an abrasive member is desired that has considerable mass it is possible to add together quantities of urethane and the heavier vinyl foam.

Still another advantage of the invention is that open cell foams, i.e. foams in which the cells are formed by interconnected stalks, can be employed to advantage. They permit proper compression and, which can be important, they provide pathways by which solvent — from solvent-cut binders or catalysts can escape. Solvent-cut binders can be advantageous in bonding the foam body members together, as they can provide good coverage of the foam body members without introducing such an amount of solid material as to detrimentally decrease the resiliency of the structure.

A still further advantage of the invention, which has particular economic importance, is the fact that scrap or waste foam, for instance cuttings and clippings of 2 pound per cubic foot urethane foam can be ground to the desired size, in the preferable range of one-half inch to one-sixteenth inch diameter balls or cubes.

Yet another feature of the invention is the simplicity and ease of control of the forming process.

According to the preferred method of the invention, first there is obtained a large number of discrete, preformed resilient foam body members, preferably, from the point of view of tear strength, foams from the urethane or vinyl classes, or similar resiliently extensible and compressible foams, e.g., silicone rubber, or ionomer foams. In general the foams should have an ultimate tensile strength of at least 5 psi, and preferably substantially greater. It is preferable that the foams be capable of 50 percent elongation or greater before break. For most applications for driven machines such as grinders and sanders, the foam should retain these properties at temperatures up to at least 150°F. and preferably higher. For high speed applications the foam should resist degradation at temperatures up to 200°F.

Preferably these foams are selected from bedding-weight (including cushion, pillow and padding weight) foams, preferably being scrap foam, and presently most preferably there is employed an open cell urethane foam of a density on the order of 2 pounds per cubic foot.

The foam, whether scrap or slab in its solid formed state, can be processed by known grinding or comminuting machines, and reduced to the size appropriate to the particular application. A lower limit of the size of the major portion by weight of the foam body members exists, though dependent somewhat on the particular application. It is necessary to provide a substantial number of freely compressible cells in the completed abrasive member in which portions of each cell can elastically shift relative to one another, to achieve the desired properties, and of course some of the cells at the periphery of each body member are not very free due to the bonding material.

On the other hand, depending somewhat upon the application, there is a limit to the largeness of the major portion by weight of the preformed foam body members. Their preformed size determines their compressed size under any given pressure conditions and the uniformity of the distribution of grains. The permissible range varies but in many advantageous instances the sizes of the major portion by weight of the body members will be within the range of about one-sixteenth inch to one-half inch, and preferably in the range of one-eighth to three-eighths inch.

While the invention makes extremely advantageous use of low density foams (densities of less than 5 pounds per cubic foot), situations are envisioned where higher density foams will be usefully employed in accordance with the broader aspects of the invention. For instance, higher density foams may be used to obtain greater foam strength or to enable use of foam materials which have insufficient strength for the particular application at hand at the lower densities.

With regard to the large number of abrasive grains employed, the grain size can vary over a particularly wide range. This is of advantage since the ability to employ quite heavy and large grains is desirable, i.e., for scratch finish work. In any event, however, the individ-

ual grain size is substantially smaller than the size of the body members in their uncompressed, and indeed in most instances in their compressed state.

So far as the bonding material is concerned, at least the portion of the bonding material immediately bonding the resilient body members is of a flexible nature, this preferably being more than half by weight of the bonding material. As will be discussed below, the bonding material adjacent the grains may be flexible to a lesser degree.

At least in the region of the grains, the bonding material must demonstrate tough and tenacious qualities, and generally must have considerable tacking during mixing, to ensure uniform distribution, this being particularly important in the case of the larger abrasive grain sizes.

Generally, if two bonding materials are employed, the first is a tacky viscous bonding material applied to the grains and the second is a resilient bonding agent which is less tacky and viscous, but has greater covering power. Advantageously, the first bonding agent may then provide a more rigid bond than the second.

The proportions of the three major components of the abrasive work region, i.e., the resilient foam body members, the abrasive grain, and the bonding material can be varied over a considerable range, depending upon the particular application intended for the final product, and the specific nature of the particular components being employed.

In the preferred embodiment in which very low density foam body members are employed, e.g., polyurethane open cell foams having a preformed density of about $1\frac{1}{2}$ or 2 pounds per cubic foot, the relative amounts of the various components preferably fall within certain limits. Thus, in the case of making a generally homogeneous abrasive wheel of 8 inch outer diameter and 2 inch thickness, the mass of foam body members may weigh between about three-fourths pound and one-fourth pound, with the preferable range being between one-half and five-eighths pounds. At the same time the amount of abrasive grains, depending on grain size, application, etc., may fall within the range of one-half pound and 5 pounds. The bonding agent then will be present in substantial excess over that which would be necessary to bond the foam body members into a coherent mass in the absence of grains. Depending most significantly on the amount of grain present, the solids content of the bonding agent may range between about one-third and 1 pound within the preferred amount in many instances of one-half pound of solid material.

Depending upon the application, there are a wide variety of flexible bonding agents and mixtures thereof that may find applicability. In some instances for instance vinyl binders such as poly vinyl acetate and poly vinyl butyral may be employed. In other instances epoxy with suitable conditioning agents, i.e., plasticizers, can be employed.

The preferred bonding agents, at least for joining the foam body members, are those which are of a resilient or elastomeric nature. Particularly good results have been obtained using resilient or elastomeric polyurethanes. Generally such elastomers are prepared from aryl diisocyanates and polyols selected from diols and high molecular weight triols. Usually the molecular weight of the diols may be selected over a broad range, e.g., 62 to 2,000. The triols will usually have molecular

weight between about 675 to 5,000. When it is desired to have a less flexible bond the polyurethane may be formed from a combination comprising for example a major proportion of the diols and lesser proportions of lower molecular weight triols, e.g., having molecular weight below 675. As an example of a less flexible polyurethane mention may be made of Vultathane R-66-21 (trade name of General Latex and Chemical Corp., Cambridge, Mass.) for a polyurethane having about 6.6 percent by weight reactive isocyanato groups, formed from toluene diisocyanate and a mixture comprising polypropylene glycol (m.w. about 1,000) diethylene glycol and trimethylol propane. For obtaining adequate flow, this 70 percent solids binder incorporates a solvent mixture xylol and 2-ethoxy ethanol acetate.

As an example of a more flexible binder mention may be made of Vultathane 15-S-9. (Trade name of General Latex and Chemical Corporation for a polyurethane having about 9.5 percent by weight reactive isocyanato groups and formed from toluene diisocyanate and a mixture of polyoxypropylene glycol (m.w. about 2,000) and a polyoxypropylene triol (m.w. about 3,000).

In certain preferred embodiments of the present invention a combination of coating solutions are preferably used for applying the binder to the grains and resilient body members. A first coating solution which is quite viscous and tacky is used to coat the abrasive grains and a second coating solution which is more fluid and less tacky and having better covering power is used to wet the resilient body members.

Such an embodiment further provides that a substantial amount of the bonding agent will be retained on the grains even after mixing, holding them in place, thereby providing more durable abrasive grain qualities. This embodiment has been found especially useful when employing 60 mesh and coarser grains. Generally the less viscous coating solutions may be prepared by merely diluting the first coating solution with a suitable solvent. However, when desired coating solutions of a different nature may be employed. In an especially useful embodiment of this type the first coating solution comprises a bonding agent which will provide a more rigid (but still resilient) bond than that of the second coating solution. It has been found that the use of such a combination of rigid and less rigid bonding agents provides a gradual transitional bond between the abrasive grains and the resilient body members and results in an improved abrasive member, with improved retention of the grains in the abrasive member.

Further improved products can be achieved by special treatment of the abrasive grains before contact with the bonding agent. Thus the grains may be heated before combination with the agent. This has the advantage of removing the moisture, making room in the small surface openings for entry of the bonding agent. It also ensures a substantially continuous, foam-free interface between the bonding agent and the grains.

Also, it is found to be advantageous in some instances to mix the grains while still hot with the bonding agent, which not only ensures against moisture, but also enables an initial cure of the bonding material at the interface, which helps to ensure that bonding material will remain at the interface after mixing with the resilient foam body members.

In other instances it has been found possible to use a single bonding agent and to employ no special efforts to remove moisture from the grains.

Furthermore, with regard to the bonding material, it is presently usually preferable that the bonding material provide a continuous bridge between the abrasive grains and the foam body members, that is, that the bonding material be substantially unfoamed. When the bonding material is urethane this may be accomplished by using known non-foaming curing systems, e.g., reacting the active isocyanato groups of the urethane with polyols such as the diols. When water is employed in the cure, foaming may be suppressed by avoiding the use of foam stabilizers. The compressive forces of the mold also act to suppress any foaming tendency. It is further possible to reduce foaming by applying a vacuum during mixing to remove gaseous products.

For forming a preferred embodiment a preferred mixing procedure for the ingredients is as follows:

1. Place a predetermined large quantity of abrasive grains in a mixer.
2. While mixing, add a first bonding agent in non-cured, viscous, tacky form, until the grain is substantially covered.
3. Thereafter, as an optional step, while still mixing, add a relatively fluid second bonding agent, also in non-cured, liquid form.
4. Introduce a predetermined quantity of preformed foam body members mixing at lower speed. The quantity in most instances for abrasive members that can conform to contours should be sufficient when compressed to occupy more than one half of the volume of the abrasive member.
5. Introduce a relatively flexible second bonding agent simultaneously with the foam body members, this agent being more fluid than the first agent.
6. Mix thoroughly, and 7, place into a mold, compress a predetermined degree and cure bonding agent, e.g., by heating while the mass is under compression. material is concentrated upon the grains. Thereby they are rendered tacky, and, under mixing conditions, it is found that the tumbling body members will pick them up and disperse them throughout the mixture. Obviously for every grain picked up,

Another preferred mixing procedure is as follows:

1. Place a predetermined large quantity of preformed foam particles in a mixer.
2. After a short period of mixing, add a flexible bonding agent in its fluid tacky state and mix thoroughly.
3. Introduce a predetermined quantity of abrasive grains and mix thoroughly, adding such catalysts or reactants as may be required by the bonding agent.
4. Place into a mold capable of exerting pressure or dispose between other compression members such as travelling belts that are forced together or pressure rollers, compress a predetermined degree and cure the bonding agent.

In the mold, when compression is applied, it is assured that the bridge of bonding material is subjected to compression, hence a pressure bond is formed. Simultaneously, it is assured that bonding material interposed between adjacent body members will pressure-bond them together. By being surrounded by bonded body members, many of the foam body members themselves are retained in the state of substantial compression

when the mass is removed from the mold. Also it is to be observed, that by there being only a limited quantity of bonding material, and it being applied so as to remain on the periphery of the body members, therefore, even in the case of open cell foams, the parts of the resilient cells within the foam body member are maintained free to move relative to one another even if they contact each other. Thus the parts of the cells, under working stress, can shift relative to one another, and align with the direction of stress, thus allowing the abrasive member to resiliently deform.

Referring now to the drawings:

In FIG. 1 there is diagrammatically shown a single preformed, cured open cell urethane foam body member 10 on an enlarged scale. The body member is of generally irregular form having a maximum dimension or diameter D in the range of one-half to one-sixteenth inch and a minimum dimension D1 preferably also within the same range. In the center of FIG. 1 there is shown a circle, which represents a microscope eye piece of substantial power, and within that circle are illustrated the tiny integrally interconnected stalks 12 of the open cell foam. The stalks in the cured state are solid, and resilient and free to stretch independently. They also provide a degree of resistance to compression, and when compressed together, substantially more resistance to compression, enabling compressional force to be transmitted through the body members to the bonding agent on the abrasive grains.

In FIG. 2 there is diagrammatically shown, on an enlarged scale, a mass of abrasive grains 14 each provided with a coating of a not fully cured bonding agent 16.

In FIG. 3 there are diagrammatically shown, on an enlarged scale, two discrete preformed foam body members 10, 10', to which cling, in a dispersed manner, a number of the abrasive grains 14 by means of the bonding agent 16 previously applied to the grains.

Also shown on the body members are a number of thin masses 18 of additional bonding agent which preferably is relatively flexible as compared to the bonding agent 16 applied to the grains.

Referring to FIG. 4 there is shown a pair of opposed mold pressure plates 20, 22 which are forcibly urged together and between which reside a large number of the discrete body members 10 carrying on their peripheries an even larger number of abrasive grains 14 by means of bonding agent 16, and also the thin masses 18 of additional bonding agent.

As shown, the body members are compressed to substantially smaller dimensions due to the pressure applied by plates 20, 22. It will be understood that the mixture is confined on all sides by the mold, and behaving somewhat as a fluid, compressional forces are exerted in all directions and the preformed body members are therefore compressively deformed in all directions to substantially smaller dimensions, the degree of compression depending upon the amount of void space and hardness desired for the final product.

Thus it will be seen that during the mixing stage, when the body members were not so greatly compressed, they afforded a substantial surface area to which the abrasive grains 14 and the additional bonding masses 18 could adhere. However during molding under the considerable compression of the mold, the peripheral area of the body member is substantially decreased, the ratio of bonding agent to surface area increases, and the bonding agent masses 16 and 18 be-

come effective to bond the entire composition together, upon curing.

In addition to the fact of coverage achieved by the relatively small volume of relatively expensive bonding agent, the compression also yields advantages with respect to the strength of the bond between body members and between grains and body members. Referring to FIG. 5 parts of body members 10 and 10' are shown between which is confined an abrasive grain 14. The pressure of the plates 20, 22 (FIG. 4) applied through the compressed body members 10 and 10' cause pressure contact between the peripheries of the body members and the bonding agent 16 and also between the surface of the abrasive grains 14 and the bonding agent, providing a substantially higher strength bond, per unit cross-sectional area, than would be achieved in the absence of the substantial pressure that is permitted by the cell structure of the foam having been previously formed.

Referring to FIG. 5a in dotted lines there is shown diagrammatically an open cell of cured foam, which consists of a number of stalks 30 joined to form a three dimensional cell, though shown here as a pentagon. Under the compression achieved in FIG. 4, the cell is resiliently deformed so that substantial parts of the stalks contact one another, but void space remains and the stalks are still free to separate or move relative to one another under the influence of working stress.

It should be understood that after curing, when the pressure of the mold is released, the abrasive member does not expand substantially, due to the restraint offered by the bonding material. Nevertheless, the walls or stalks of many of the cells in the interior of the body members, being resilient and under compression, have a latent tendency to expand. This pre-stressed internal condition is believed to contribute to the favorable properties of the abrasive member. After an abrasive member has been used, a "fuzz" or low density component can be observed at the surface which is believed to evidence an expansion of the cells as the abrasive member wears away. It is observed that abrasive members according to the invention resist glazing or loading with metal or wood particles, and it is believed that this expansion tendency of the cells plays a part in obtaining this favorable performance.

Referring to FIG. 6 there is shown a bond similar to FIG. 5 except that the preferred multiple coating of bonding agent had been previously applied to the abrasive grain 16, hence the periphery of the flexible body member is bonded to a relatively more flexible bonding agent 18 than is the rigid grain 14, which is bonded by the contact bonding agent 16. The interface between the two bonding agents involves less of a contrast of flexibility than would either the interface between body member 10 and contact bonding agent 16 or the interface between abrasive grain 14 and flexible bonding agent 18, hence an improved bond is achieved.

It will be understood that the figures previously referred to have exaggerated to some extent the thickness of the bonding agent for purposes of illustration. Nevertheless it will be understood that the thickness of the bonding agent, in the vicinity of the abrasive grains, can be of considerable thickness and is sandwiched between and supported by the body member 10 and the abrasive member 14. Thus it can be appreciated that the strength and tear resistance of the bond that is achieved is substantial and the abrasive grains are se-

curely retained. The weakest region may thus be the foam body member itself and when it fails, new grains can be exposed, to renew the abrasive working surface.

Referring to FIG. 7 work piece 31 is shown to which flexible abrasive member 26 of the invention conforms as it moves to alter the surface of the work piece. Such conformability is possible regardless of whether the form of the abrasive member is wheel, disk, block, belt, etc. It is possible with the internal structure of FIG. 4, but in FIG. 7 a layered internal structure is shown.

According to this aspect of the invention a Layer L is formed of preformed foam body members 10a (see the magnification denoted by the circle). These foam members are compressed from their original size, flattened into the sheet-form layer, with flattened planes generally aligned with the plane of the layer. Flexible bonding material 18a is applied to the foam members when they are compressed, thus causing them to be pressure bonded into the form of layer L.

Preferably after formation of layer L, abrasive grains 14a are applied to one or both faces of the layer and secured by bonding material 16a, preferably while pressure is applied, to form a pressure bond.

Such an abrasive layer may be used by itself, but preferably it is bonded with similar layers into a sandwich with exposed edges E of the layers oriented to define the working surface of the abrasive member.

FIG. 8 illustrates a grinding wheel that can be formed according to the invention.

FIG. 9 illustrates an abrasive member formed to provide a working surface 40 and a handle 42, suitable for hand sanding and polishing. Such a construction may be molded from two batches of foam, one only containing abrasive grains, forming the lower portion defining the working surface 40.

There follow selected examples which also serve to illustrate salient features of the invention. Following the examples certain important features of the invention, illustrated by the examples, are discussed.

EXAMPLE I

A grinding wheel was formed according to the following procedure:

1. 52.0 oz. of 60 grit (size) silicon carbide abrasive grains were introduced into a mixer, e.g., a Hobart (trademark) orbital mixer.
2. While mixing 2.1 oz. of an uncured urethane bonding agent was introduced, to the mixer, specifically a binder known as R-66-21, 70 percent solids "Vultathane," sold by the General Latex and Chemical Corporation, of Cambridge, Massachusetts. This binder is tacky and viscous and has high toughness when cured.
3. Following thorough mixing a second uncured bonding agent was introduced, being 5.3 oz. of a relatively flexible urethane diluted with mineral spirits, specifically a 75 percent solids binder known as 15-S-9Q "Vultathane" sold also by the General Latex and Chemical Corporation.
4. As a previous step, there was provided 8 oz. of previously cured polyurethane foam of a density on the order of 2 pounds per cubic foot, in the form of open cell scrap bedding foam and this was ground into discrete body members of one-eighth inch average diameter. (For this purpose a "Scottdel Impact Grinder" made by Scottdel, Incorporated of Swanton, Ohio may be employed.)

The preformed foam body members were gradually introduced into the mixer, with the mixer operating at low speed.

5. Simultaneously with step 4, 12.3 oz. more of 15-S-9Q "Vultathane" were gradually added to the mixer, and thereby applied to the surfaces of the body members.
6. After adding 150 cc of water and mixing for 4 minutes from the beginning of the addition of the foam members, the mixture was placed into an annular mold having a 10 inch outer diameter and a 2 3/4 inch inner diameter. The entire mixture was compressed to a predetermined thickness (axial dimension) of 2 inches. So compressed, the mold was placed in a 350°F oven and baked for 1 1/2 hours, curing the bonding material in the compressed condition. (For closing such a mold a force of about 100 pounds is required, and to retain it closed during cure a clamping force of about 50 pounds is required). After removal from the mold the wheel is allowed to stand under ambient conditions to conclude the cure. The following calculated volumes were obtained:

B₁ = Bonding Agents
G₁ = Silicon Carbide (60 Grit)
F₁ = Polyurethane Foam (solids portion)
W₁ = Water
V₁ = Voids

P₁ = 64.5

VOLUME
16.0%
19.5%
8.5%
6.5%
49.5%
100.0%

For these calculations the solids portions of the binder and foam were assumed to have a specific gravity of 1.1 and the non-solid portion of the binder was assumed to have been volatilized. The silicon carbide grains were assumed to have a specific gravity of 3.2.

It is realized that the foam particles, internally and between each other, are the significant factor in providing the void space. This volume was calculated by adding items V, F and W together, the sum denoted by P (porous volume). The calculation was based on the assumption that all water is evaporated, although some predetermined minor amount probably remains.

The resulting abrasive wheel demonstrated an average hardness reading of 55 durometer on the Shore "A" scale (type A2 instrument), and is suitable for contoured work, and as a general purpose wheel, i.e., for producing a satin finish on metal, for deburring metal and for wood sanding.

EXAMPLE 2

The same procedure as Example 1 was followed with the following changes in the respective steps:

1. 32.0 oz 0.60 grit silicon carbide
2. 2.1 oz. of R-66-21
3. Omit
4. Same amount and type of ground scrap foam as Example 1.
5. 7.0 oz. 15-S-9Q
6. 150 cc of water, compress into annular mold 8 inch outer diameter, 2 3/4 inch inner diameter, 2 inch thick, baked at 350°F for 1 hour.

The following calculated volumes were obtained:

B₂ = Bonding Agents
G₂ = Silicon Carbide (60 Grit)
F₂ = Polyurethane Foam
W₂ = Water

VOLUME
12.0%
20.0%
14.5%
10.5%

V₂ = Voids

P₂ = 68.0

43.0%
100.0%

The resulting abrasive wheel demonstrated a durometer of 75 on the Shore A: scale and was suitable for flat work.

EXAMPLE 3

Following Example 1:

1. 48.0 oz. 36 Grit Aluminum Oxide.
2. 7.0 oz. 15-S-9Q.
3. Omit.
4. 16.0 oz. of foam body members per Example 1.
5. 10.6 oz. R-66-21.
6. 200 cc water, compressed under light pressure into an annular mold of 10 inch outer diameter, 2 3/4 inch inner diameter and 4 inch thickness, baked for 3 1/2 hours at 325°F.

The following calculated volumes were obtained:

B₃ = Bonding Agent
G₃ = Aluminum Oxide (36 Grit)
F₃ = Polyurethane Foam
W₃ = Water
V₃ = Voids

P₃ = 86.0

VOLUME
7.0%
7.0%
9.0%
4.0%
73.0%
100.0%

For this calculation the specific gravity of aluminum oxide was assumed to be 4.0.

The resultant wheel demonstrated very substantial resiliency and flexibility, with an estimated hardness of 35 durometer on the Shore A scale. It conformed very well at low speeds for decorative scratch finishing of curved metal surfaces, light sanding of wood and floor scrubbing. The abrasive grain suffered substantial loss, but still remained effective.

EXAMPLE 4

A grinding wheel was formed by modifying the procedure used in Example 1 as follows:

1. 17.3 oz. of previously cured polyurethane foam ground to a particle size of one-eighth inch average diameter was introduced into a HOBART mixer.
2. After 2 minutes of mixing, 31.0 oz. of VUL-TABOND 15-S-9, being an uncured bonding agent of flexible urethane, containing 100 percent solids, (sold by the General Latex and Chemical Corporation of Cambridge, Mass.) was added to the ground polyurethane foam previously introduced into the HOBART mixer.
3. After 3 additional minutes of mixing 59.75 oz. of 40 grit (size) silicon carbide abrasive grains were added to the above mix.
4. After 2 additional minutes of mixing 162 cc of water was added to the above mix; after 3 additional minutes of mixing the mixer was shut off and the mixture was placed in a rectangular box 23 inches × 20 3/4 inches in size. The entire mixture was then compressed to a predetermined thickness of one-half inch in a hydraulic press and cured for 15 minutes at a temperature of 240°F. The member was removed from the mold and allowed to age for two days under ambient conditions during which further curing occurred. A test wheel was cut from the resulting sheet. The resulting abrasive wheel when tested with a Shore "A-2" scale tester gave an average hardness reading of 59 durometer. Calculating the comparative volumes of the various

ingredients in this abrasive wheel (assuming a specific gravity of 1.1 for this bonding agent also) the following figures were obtained:

	VOLUME
B ₄ = Bonding Agent	21%
G ₄ = Silicon Carbide (40 Grit)	14%
F ₄ = Polyurethane Foam	12%
W ₄ = Water	4%
V ₄ = Voids	49%
	100%

P₄ = 65.0

This wheel is particularly suitable for wood finishing and may be readily formed to a predetermined shape. For instance the profile of a desired wood molding may be formed in the arcuate face of the wheel by removing part of the moving wheel body, the wheel retaining this profile to effectively finish wooden moldings.

EXAMPLE 5

The same general procedure as Example 4 was followed but having the following changes incorporated in the respective steps:

1. 13.5 oz. of ground polyurethane foam (one-eighth inch size)
2. 9.25 oz. of Vultabond 15-S-9
3. 40.25 oz. of silicon carbide grain (40 grit)
4. 48 cc of water
5. The entire mixture was compressed to a thickness of one-fourth inch in the mold used in Example 4.

The following calculated volumes were obtained:

	VOLUME
B ₅ = Bonding Agent	12.5%
G ₅ = Silicon Carbide (40 grit)	18.5%
F ₅ = Polyurethane Foam	18.0%
W ₅ = Water	2.5%
V ₅ = Voids	48.5%
	100%

P₅ = 69.0

The Shore A-2 reading of a wheel cut from the sheet averaged 66 durometer. This wheel is a good general purpose wheel and is particularly effective in finishing titanium metal.

EXAMPLE 6

The same general procedure as Example 4 was followed but having the following changes incorporated in the respective steps:

1. 24 Oz. of ground polyurethane foam (one-fourth inch size)
2. 18 Oz. of Vultabond 15-S-9
3. 48 Oz. of silicon carbide grain (60 grit size)
4. 70 cc of water
5. The entire mixture was compressed in the same manner as Example 4, but to a predetermined thickness of one-fourth inch.

The following calculated volumes were obtained:

	VOLUME
B ₆ = Bonding Agent	24.0%
G ₆ = Silicon Carbide (60 grit)	22.0%
F ₆ = Polyurethane Foam	32.0%
W ₆ = Water	3.7%
V ₆ = Voids	18.3%
	100%

P₆ = 54.0

The Shore A-2 scale durometer reading of this wheel averaged 81 durometer. A grinding wheel cut from the resultant sheet demonstrated usefulness for general purpose grinding, having good flexibility and durable properties.

EXAMPLE 7

The same general procedure as Example 4 was followed but having the following changes incorporated in the respective steps:

1. 8 Oz. of ground polyurethane foam (one-eighth inch size)
2. 14 Oz. of Vultabond 15-S-9
3. 198 Oz. of aluminum oxide grain (40 grit)
4. 90 cc of water
5. The entire mixture was placed in a substantially square box 14 ½ inches × 14 ¼ inches in size and the entire mixture compressed to a predetermined thickness of 1 inch.

The following calculated volumes were obtained:

	VOLUME
B ₇ = Bonding Agent	11.0%
G ₇ = Aluminum Oxide (40 grit)	41.5%
F ₇ = Polyurethane Foam	6.0%
W ₇ = Water	2.5%
V ₇ = Voids	39.0%
	100.0%

P₇ = 47.5

The Shore A-2 scale reading of this wheel averaged 73 durometer. A grinding wheel cut from the resulting sheet was very aggressive and particularly suitable for grinding ferrous metals where it is desirable to rapidly remove a considerable amount of metal and still have a reasonably fine finish.

EXAMPLE 8

The same general procedure as Example 4 was followed but having the following changes incorporated in the respective steps:

1. 16 Oz. of ground polyurethane foam (one-eighth inch size)
2. 20 Oz. of an epoxy resin bonding agent consisting of 12.5 Oz. of Epon Resin No. 815 and 7.5 Oz. of Epon Curing Agent V-25 sold by Shell Chemical Co.
3. 67 Oz. of silicon carbide grain (60 grit size)
4. None
5. The entire mix was placed in a substantially square box 14 ½ inches × 14 ¼ inches in size and compressed to a predetermined thickness of one-half inch in a hydraulic press and cured for 1 hour at a temperature of 250°F.

The following calculated volumes were obtained:

	VOLUME
B ₈ = Bonding Agent	29.2%
G ₈ = Silicon Carbide (60 grit)	35.1%
F ₈ = Polyurethane Foam	24.6%
V ₈ = Voids	11.1%
	100.0%

P₈ = 35.7

The shore A-2 reading of this wheel averaged 96 durometer. A grinding wheel cut from the resulting sheet was very hard and accordingly very durable, being particularly suitable for precision grinding applications. It displays a degree of resiliency making it deformable without the danger of shattering that exists with vitrified wheels.

EXAMPLE 9

Following Example 1:

1. 40.0 Oz. 60 Grit Silicon Carbide
2. 3.5 Oz. R-66-21
3. 3.5 Oz. 15-S-9Q

15

4. 12.0 Oz. of scrap vinyl foam of a density of about 6 pounds per cubic foot, reduced to the general form of cubes of one-half inch length

5. Omit

6. 150 cc water, compressed into the same size and shape as Example 2, baked at 350°F for 2 hours.

The following calculated volumes were obtained:

	VOLUME
B ₉ = Bonding Agent	9.0%
G ₉ = Silicon Carbide (60 grit)	24.5%
F ₉ = Vinyl Foam	19.0%
W ₉ = Water	10.5%
V ₉ = Voids	37.0%
	100%

$$P_9 = 66.5$$

The specific gravity of the vinyl foam was assumed to be 1.25. The resultant grinding wheel demonstrated an irregular surface with an average reading of 60 durometer on the Shore A scale. The wheel was suitable for abrasive action upon wood and ferrous and non-ferrous metals. It demonstrated an aggressive cutting action and excellent wear.

EXAMPLE 10

The same general procedure as Example 4 was followed but having the following changes incorporated in the respective steps:

1. 19.3 Oz. of ground Ionomer Closed Cell Foam of a density of approximately 2 pounds per cubic foot (preformed body members of one-half inch average diameter) supplied by The Gilman Brothers Company, Gilman, Conn., reported to be manufactured from Dupont trademark "Surlyn" resin.
2. 34.5 Oz. of Vultabond 15-S-9.
3. 66.2 Oz. Silicon Carbide (60 grit size).
4. 180 cc of Water
5. The entire mixture was compressed in the same manner as Example 4, but to a predetermined thickness of one-half inch.

The following calculated volumes were obtained:

	VOLUME
B ₁₀ = Bonding Agent	23.0%
G ₁₀ = Silicon Carbide 60SC	15.5%
F ₁₀ = Ionomer Foam (assumed specific gravity of 95)	15.0%
W ₁₀ = Water	4.5%

$$V_{10} = \text{Voids}$$

$$42.0\%$$

$$P_{10} = 61.5$$

The Shore A-2 scale reading of this wheel averaged 70 durometer. This wheel exhibited grinding properties similar to a wheel having polyurethane foam substituted for the Ionomer Foam.

EXAMPLE 11

The same general procedure as Example 4 was followed but having the following changes incorporated in the respective steps:

16

1. 19.3 Oz. of silicon rubber foam (one-eighth inch average diameter) supplied by Greene Rubber Co. of Cambridge, Mass., approximate density of 2 pounds per cubic foot.

2. 34.5 Oz. of Vultabond 15-S-9

3. 66.2 Oz. Silicon Carbide (60 grit size)

4. 180 cc of Water

5. The entire mixture was compressed in the same manner as Example 4, but to a predetermined thickness of one-half inch

The following calculated volumes were obtained:

	VOLUME
B ₁₁ = Bonding Agent	23.0%
G ₁₁ = Silicon Carbide 60Sc	15.5%
F ₁₁ = Silicon rubber foam (assumed specific gravity of 1.1)	13.0%
W ₁₁ = Water	4.5%
V ₁₁ = Voids	44.0%
	100%

$$P_{11} = 61.5$$

Silicon rubber 1.1

- 20 The Shore A-2 scale reading of this wheel averaged 70 durometer. This wheel exhibited grinding properties similar to a wheel having polyurethane foam substituted for the silicon rubber foam.

- 25 In the foregoing examples use tests and hardness tests were made. Use tests are considered to be the best proof of usefulness. In making the hardness tests an average of a number of readings were taken and far-off readings were disregarded, since an unusually low or high reading indicates that the tester has struck a void space on an abrasive grain, respectively. It should be understood that the hardness readings constitute an average which is not precisely accurate but is generally indicative of a characteristic of the abrasive members.

- 35 To test for uniformity in production of abrasive members of the contour-conformable grades it is found that workmen can readily detect variation in softness and flexibility from a pre-established standard abrasive member by comparing the degree of deflection by hand, e.g., by deflecting a sheet between thumb and forefinger, or by subjecting the abrasive member to a standard bonding.

The foregoing examples are summarized in the following table:

VOLUME DISTRIBUTION

Example	Durom-eter	Volume percent						G, abra-sive grains
		P, total porous	V, void	F, foam solids	W, vola-tile	B, bond-ing agent		
1.....	55	64.5	49.5	8.5 u	6.5	16.0 (1)		19.5
2.....	75	68.0	43.0	14.5 u	10.5	12.0 (1)		20.0
3.....	35	86.0	73.0	9.0 u	4.0	7.0 (1)		7.0
4.....	59	65.0	49.0	12.0 u	4.0	21.0 (2)		14.0
5.....	66	69.0	48.5	18.0 u	2.5	12.5 (2)		18.5
6.....	81	54.0	18.3	32.0 u	3.7	24.0 (2)		22.0
7.....	73	47.5	39.0	6.0 u	2.5	11.0 (2)		41.5
8.....	96	35.7	11.1	24.6 u		29.2 (3)		35.1
9.....	60	66.5	37.0	19.0 v	10.5	9.0 (1)		24.5
10.....	70	61.5	42.0	15.0 i	4.5	23.0 (2)		15.5
11.....	70	61.5	44.0	13.0 s	4.5	13.0 (2)		15.5

Comparison of examples 1 and 2 illustrates that with essentially the same amount of abrasive grains, and, notably, with decreased volume of bonding agent, increased hardness is attainable by varying the nature of the porous volume, increasing foam solids within the specified limits. Note that this is markedly different from a mere increase in the degree of compression, for that would result in an increase in the grain and bonding agent percentages.

Example 3, an embodiment suffering substantial grain loss but with a high degree of conformability to

the work piece, represents an approximate minimum of bonding agent and durometer obtainable with low density foams and is a member near the upper limit of the magnitude of the porous volume.

Examples 4, 5, and 6, illustrate three different hardness levels using a given bonding agent (an agent different from the preceding examples), again with the porous volume playing an important roll. Example 6 is close to the preferred lower limit (50 percent) of the range of porous volume to achieve abrasive members capable of conforming to decided contours, with durometer generally below 85. This example also approaches the preferred maximum (about 40 percent) of foam solids.

Example 7, is close to the maximum for the volume of abrasive grains, lacking durability but demonstrating a very aggressive cut. This example is close to the minimum (5 percent) of foam solids to obtain some benefits of the invention. (For durable members the preferred lower limit of the solids portion of the foam is 10 percent).

Example 8 approaches the lower limit of the total porous volume for the low density foam, and represents a construction capable of replacing vitrified wheels. It approaches the minimum (10 percent) of voids necessary to obtain the advantages of the invention. The resilience, although slight, contributes significantly to improved performance, as noted. This construction also approaches the upper limit (30 percent) of bonding agent for grinding member applications. It also illustrates use of a third type of bonding agent.

Example 9 illustrates vinyl foam and approaches the preferred 30 percent lower limit of void space for members capable of conforming to contours. Example 10 illustrates ionomer foam and example 11 illustrates silicone foam.

The examples given generally represent abrasive members suitable for use as driven members, with maintained strength properties from ambient up to at least 150°F, and in general considerably higher. These thus represent compositions of quite wide operability. For other conditions, e.g., in the case of hand operated abrasive members such as sanding and finishing blocks and sheets, other foams and bonding agents find applicability, mention being made of resiliently extensible and compressible alkyd-type polyester foams containing considerable amounts of plasticizer, polyethylene foams, and rubber foams. For most applications it is preferred that the foam demonstrate a tensile strength of at least 5 psi and an elongation of at least 50 percent before break, using ASTM-D 1,564-64-T. For durable members for use, e.g., on driven machines the minimum tensile strength of the foam is preferably 10 psi. For other bonding agents mention is made of such bonding agents as polyvinyl acetate liquid adhesive, for instance aerotex 161 produced by American Cyanamid and acrylic latex emulsions, for instance Vultacryl A-111 produced by General Latex and Chemical Corporation, and see above. The degree of flexibility needed for the bonding agent varies depending upon the hardness of the desired abrasive member. For softer members, capable of conforming to contours it is preferred that the bonding agent when formed into a film demonstrate an elongation of at least 50 percent before break, and a tensile strength of at least 200 psi, under standard film-strength test conditions, e.g., ASTM-D-882-61T. It will be understood that the required

strength of the bonding agent (as well as that of the foam) varies depending upon the strength of the desired abrasive member. Thus in the case where it is desired that the abrasive member rapidly crumble away, e.g., to expose new abrasive grains or resist a tendency for the pores of the member to "load" or fill with the substance of the work piece being finished, the strength will be selected in the lower region of the strength range. For durable abrasive members for use with driven machines the strength of the bonding agent should exceed about 2,000 psi.

The nature of the abrasive grains also varies. For abrasive members for sanding wood articles the grains generally vary between about 16 and 80 grit size. For grinding metal articles the range is wider, from 16 for the roughest deburring to about 240 grit. For fine finishing, finer grains may be employed. The chemical nature of the grains is unimportant, and the choice of grain strength and shape follows the usual technology, except that, in comparison with a rigid vitrified grinding wheel, the same size grit in a resilient wheel according to the invention will provide a finer finish, the degree of fineness increasing with increased flexibility of the abrasive member.

In the preferred process of formation of tumbling the abrasive grains and the foam body members together in the presence of the tacky bonding material, it is important for best results to increase the surface area of the uncompressed foam body members when increasing the quantity of the abrasive grains, particularly in the case of grains of small grit number, in order to ensure proper distribution through the mass during mixing. It is surprisingly found that when tumbling foam particles having a density within the range of one-half pound and 5 pounds per cubic foot, and average particle size within the range of about one-half and one-sixteenth inch, in the presence of tacky bonding agent and abrasive grains of much higher density, the grains can be well distributed through the mix without either the grains accumulating at the bottom or the foam particles clumping together without abrasive grains.

Of necessity, the specific properties needed for a given abrasive member and the permissible forming procedures therefor vary widely, just as do the many conditions of industrial and domestic use. Certain applications may require considerably different physical properties, with different starting materials and proportions, yet taking advantage of the present invention.

It will be recognized from the examples that an extremely wide range of end physical properties are achieved requiring only three ingredients mixed together according to the preferred embodiment of the invention. The technician will find it useful, in compounding the various abrasive members, to maintain the porous volume between the limits of 25 percent and 85 percent, with voids above 10 percent and foam solids above 5 percent, preferably above 10 percent. Within these limits, assuming the same starting materials, he may, to increase resilient conformability to a work piece, lower the percentage volume of the abrasive grain and increase the void space; to increase rate of cut, increase the volume of the abrasive grains, increase the volume of the bonding agent and decrease the void space; to increase strength and improve retention of grains, increase the volume of the foam solids and decrease the void space with increased compression, with perhaps increased bonding agent; to increase

resistance to heat, increase the void space and decrease the bonding agent.

In the presently most preferred practice according to the invention foam is employed with densities ranging between about one-half and 5 pounds per cubic foot, foam tensile strengths ranging between about 10 and 50 psi at ambient temperature and elongation ranging between about 150 and 500 percent at ambient temperature. According to a current practice equal portions by weight of scrap polyester type polyurethane and polyether type of polyurethane foams, each of 1 1/2 pound per cubic foot density can be employed for making an extremely wide range of abrasive products, this mixture of foam representing an average foam strength of between about 15 and 30 psi and an elongation before break of between about 150 and 400 percent. These are combined with the preferred bonding agents as mentioned in the examples to achieve abrasive members whose properties do not degrade at temperatures from ambient to beyond 150°F. (For achieving various properties however, it is possible, for the bonding agent, individually or in various combinations to use a pre polymer as a starting material or to use catalysts, or to alter the curing conditions, etc., as is known in the binder art.)

It will be appreciated that, by confining the foam to the dimensions given in the foregoing examples, the foam is in general compressed, after curing, at least 50 percent, to achieve the advantages of the invention, and that the foam body members occupy a majority of the volume of the abrasive member, apart from that occupied by the abrasive grains, and indeed, for abrasive members that can conform to definite contours, occupy the majority of the total volume, including that occupied by the grains.

It will be appreciated that the basic principles of the invention, while presently preferably employed in the manner described, may have a wider range of applicability.

For instance, instead of wearing away an abrasive member to achieve a special profile for grinding a predetermined shape, the shape itself may be employed to define the shape of a mold. For instance an automobile hub cap may be used to define the bottom of a mold for the abrasive member, and thereafter the member will fit precisely the shape of such hub caps to be finished.

In the case where only part of the resilient member is to provide a working surface, abrasive grains may be omitted from other parts. Thus, a hollow pipe may be inserted into a cylindrical mold and filled with foam body members without grain. The annulus between the pipe and the mold can be filled with a grain mixture, the pipe withdrawn with its contents remaining, and the composite mass compressed and cured. Similarly, in the case of centrifugal casting of the mass, vibrations may be introduced to cause the grain concentration in the peripheral region to be greater than the interior. Similarly, when molding abrasive blocks, the mold can be shaken to cause the grains to migrate to the working surface. On the other hand instead of molding a mass of substantial thickness, a thinner mass could be formed, either self-supporting or provided with a backing sheet with abrasive grains force-bonded to the exterior. The ultimate form of the abrasive member could consist of a belt or a wheel formed by a number of convoluted sheets bonded or loosely held together.

Advantageously, however, and in some cases essentially, the abrasive member is originally molded as a mass of substantial thickness, but then operations are performed upon it. In one instance a mass could be cast in the form of a long roll, or log, and can be used in that form. Alternatively it can be cut by a saw, for instance, into two inch thick wheels and marketed in that manner, or cut into much thinner discs, to provide greater axial flexibility. In another instance presently preferred for most applications a sheet may be molded and round or other shaped members die cut therefrom. The rolls, wheels or discs can be provided with surface cuts for purposes of cooling, increased cutting area or flexibility.

Furthermore the body of the abrasive member can incorporate other members, i.e., reinforcing members such as elastomeric, resinous, vitreous, cellulosic or animal filaments and hairs, and void producing substances. In the case voids are desired, it is possible to dispose rods, or filaments of the void producing substance in any desired arrangement and cast the material about them, after which the void producing substances can be removed, e.g., by pulling, heating for "lost wax" removal, etc.

These and numerous other modifications in form and use will be obvious to those in the art.

What is claimed is:

1. A resilient abrasive member comprising a mass of resilient, extensible and compressible polyurethane elastomeric foam having substantial tear strength and resistance to temperatures up to at least 150°F without substantial degradation and a predetermined quantity of inorganic abrasive grains, said foam being in the form of discrete, preformed body members having uncompressed dimensions between about one-half inch and about one-sixteenth inch, said grains being smaller than said foam body members and disposed among said body members, said foam body members bonded to each other and to said abrasive grains by a flexible polyurethane elastomeric bonding material having substantial tear strength and being resistant to temperatures up to at least 150°F without substantial degradation, said foam body members residing in a compressed state, the volume of the compressed resilient foam body members including the void space associated therewith being between about 25 percent and 80 percent of the total volume of the abrasive member, the total weight of said body members being less than the weight of said grains, and said bonding material being present in sufficient quantity to bond said body members and grains into a flexible coherent mass, said body members and said bonding material each being capable of flexibly distorting when said abrasive member is subjected to working stress, while resiliently and securely carrying said abrasive grains against a work piece for abrading and finishing the surface of said work piece.

2. The abrasive member of claim 1 wherein said foam body members have an uncompressed preformed density of about 1 1/2 to 2 pounds per cubic foot and the relative weights of polyurethane foam body members, abrasive grains and solids content of the polyurethane bonding material are:

polyurethane foam body members	between about 3/4 and 1/4 parts by weight
abrasive grains	within the range of 1/2 and 5 parts by weight
solids content of polyurethane bonding material	between about 1/2 and 1 parts by weight.
	* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,773,480 Dated November 20, 1973

Inventor(s) Elisha Winthrop Hall & Walter A. Sheehan

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, line 46, change "of" to --or--;

Column 5, line 13, "tacking" should be --tackiness--;

Column 7, line 40, after "compression.", start as a new paragraph and insert --The foregoing procedure ensures that the bonding--;

Column 7, line 43, "disperse" is misspelled;

Column 7, line 45, after "picked up,", insert --there is a bridge of bonding material interposed between the grain and the foam cells.--;

Column 11, line 13, "axial" is misspelled.

Signed and sealed this 16th day of April 1974.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents